Information through remote sensing to reduce Lebanon's vulnerability to desertification

Khawlie M., Faour G.

in

Gitas I.Z. (ed.), San Miguel Ayanz J. (ed.).
Environmental monitoring in the South-Eastern Mediterranean region using RS/GIS techniques

Chania : CIHEAM
Options Méditerranéennes : Série B. Etudes et Recherches; n. 46

2003
pages 17-25

Information through remote sensing to reduce Lebanon's vulnerability to desertification

M. Khawlie and G. Faour
National Center for Remote Sensing (National Council for Scientific Research)
PO Box 11-8281, Code 1107 2260 Beirut, Lebanon
e-mail: rsensing@cnrs.edu.lb

Abstract: Desertification is affecting Lebanon's environment and its resources, even though the country enjoys a fair amount of water and green cover. Many threats inducing land degradation are increasing the vulnerability of the country. The paper reveals those threats and emphasizes that facing them with proper solutions needs information. The more information, the less vulnerable is the country. Such information must be intersectorial, integrated and is best obtained through remote sensing, especially the use of indicators.

Keywords: Environment, threats, land degradation, indicators, information

Resumé: La desertification affecte l'environnement du Liban et ses ressources; le pays jouissant pourtant d'une bonne part d'eau et de couverture végétale. Plusieurs menaces favorisant la dégradation du sol rehaussent la vulnérabilité du pays. L'article révèle ces menaces et souligne la nécessité de les affronter avec de propres solutions à base d'informations utiles. Plus ces dernières sont disponibles, moins vulnérable est le pays. De pareilles informations doivent être intersectorielles, intégrées et peuvent être mieux obtenues par télédétection, notamment l'utilisation des indicateurs.

Mots-clés: Environnement, menaces, dégradation du sol, indicateurs, informations

Introduction

Although Lebanon enjoys natural conditions of precipitation and green cover that should make it less vulnerable to desertification than its neighboring Middle East countries, yet there are large areas in the country undergoing degradation. In fact, the local authorities and concerned researchers are quite worried about desertification in the country, mostly because of the added factor impacting the balance of natural ecosystems, namely, human interference (Khawlie, 2000; NAP, 2002). This factor is adding up considerably to the effects of severe climatic events, such as droughts and torrential floods, that are becoming more frequent. It is highly likely that those events are due to climate change (Khawlie, 2001; MoE, 1999) overtaking the eastern Mediterranean Region.

The vulnerability is reflected in deteriorated natural resources, i.e. water (Khawlie, 2001), forest and agriculture (Masri et al., 2002; Jomaa & Khawlie, 2002), soil (Bou Kheir et al., 2001) as well as the social fabric, socioeconomic aspects and the environment (MoE, 1995). This means an impact on the quality of living, which requires serious assessment and adaptation measures. Water availability is being reduced, forests are burnt or cut down, agricultural produce is reduced and rural communities are migrating leaving the land to further deterioration. The problem needs to be checked, because the rate of worsening of such deterioration is exponential: the further it goes the more vulnerable the land, natural resources and humans become.

The major setback facing the above is the lack of data and information, especially on updated and upgraded basis. As an example, the basic topographic maps still most in use go back to the early sixties (DAG, 1962). Studying those maps one can easily notice the huge changes that took place since. An updated green cover map was prepared by FAO from 1987 satellite imageries (FAO, 1990). Even this map shows several discrepancies compared with present day coverage. Obviously, there is a need not only for updating the information of those maps, and others, but also to monitor the various desertification processes. This is why remote sensing should play a crucial role in the monitoring and upgrading framework. Accordingly, the purpose of this paper is to reflect on the use of remote sensing in helping those concerned by supplying them updated, total and accurate information on desertification in Lebanon to reduce its vulnerability (Khawlie et al., 2001, 2002; CTM-ERS, 1999; Gentile, 1998).

Problem And Scope

The Government of Lebanon signed the Convention to Combat Desertification (CCD) in September 1995 and ratified it in December 1995 (NAP, 2002) under the auspices of the Ministry of Agriculture (MoA). Lebanon's problems in land degradation are the same as those of neighboring countries, i.e. a natural deficiency in water (Brooks, 2000; Sadek & Barghouti, 1994) but associated with a strong human interference and mismanagement of natural resources. The country's technical and financial capacities are serious constraints in coping with desertification. FAO, UNDP and the German GTZ have extended help in this regard, and a dedicated section was established for that purpose at the MoA.

If the UNCCD Article 1 is considered, which defines "desertification prone areas" through the ratio of annual precipitation to potential evapotranspiration at 0.05 to 0.65, then approximately 60% of the country falls within this range (NAP, 2002). Out of this, 40.06% covers arid and semi-arid areas, while the rest, 59.94% covers dry sub-humid and sub-humid to humid areas. The high risk areas focus mainly in the following parts of Lebanon: the North (Akkar), the Northeast (Bekaa), and the South (Fig. 1). Interestingly enough, these are the areas that had the least attention in development efforts by the succeeding governments the last five decades. They are the areas with least monitoring and information and, therefore, the most vulnerable (Table 1). The Table shows the threats facing those areas explaining their high vulnerability and susceptibility to desertification.

As shown in (Fig. 1), the three areas are under different climatic effects: N.E. Bekaa is a semi-arid to arid inland zone, Akkar is a coastal humid zone, while the South is a coastal sub-humid area. This explains some of the differences in the natural threats, i.e. N° 1 to N° 4 of (Table 1). On the other hand, the similarities of Bekaa and Akkar in threats N° 8 to N° 13, as different from the South, is explained by a higher intensity of uncontrolled human interference. Those items that are different, i.e. N° 6 and N° 7, reflect differences in the character of the area: more surface water is available in Akkar, therefore, less exploitation of groundwater, and more widespread cattle in the Bekaa explaining the overgrazing there.

Obviously, the threats are variable and cover many themes but can be grouped under two major aspects: the natural, i.e. N° 1, 2, 3 and 4, and human-made, i.e. N° 5 to N° 14 inclusive. The impacts of the threats are quite serious, and one can assume that those labeled H (high) have been deteriorating continuously to reach this high level of vulnerability. The seriousness is in the fact that the community in those areas become less adaptive to stresses. The need for impact assessment and adaptation assessment are necessary for an integrated vulnerability assessment. These assessments can be made only if information is available, which would lead to reduce the vulnerability. Since remote sensing is a valuable tool in monitoring and quick data acquisition, it is inevitable that its use is quite significant in reducing Lebanon's vulnerability to desertification.

Table 1. Vulnerability of the most desertification-prone areas in Lebanon*

N°	Threats \ Areas	N.E. Bekaa	Akkar	South
1	drought	H	L	M
2	erosion by water	H	H	M
3	erosion by wind	H	L	L
4	flash floods	H	M	L
5	water mismanagement	H	H	H
6	excessive exploitation ground water	H	M	M
7	overgrazing	H	M	L
8	uncontrolled quarrying	H	H	L
9	bad agro-practices	H	H	M
10	uncontrolled urban expansion	H	H	M
11	deforestation/forest fires	H	H	M
12	uncontrolled pesticides fertilizer	H	H	M
13	water pollution	H	H	M
14	poverty	H	H	H

*basic data modified from NAP (2002)
H: high, M: medium, L: low

Impact Assessment

Although several researchers have worked on land degradation aspects in Lebanon, and although several projects related to this issue were or still are being implemented, no national action has yet been taken following a systematic approach to assess desertification through a well-defined set of criteria (Khawlie, 2000). Moreover, even though a "LEDO"- Lebanese Environment and Development Observatory was erected at the Ministry of Environment (MoE) for the purpose of collecting indicators data on many aspects of environmental deterioration, including desertification (LEDO, 2001), it does not seem to be sustainable. The crucial problem lies in the inaccessibility of the LEDO authorities to data, or in the unavailability of indicators data/information from the different stakeholders, e.g. relevant ministries, agencies, research centers … etc. This is going on while deterioration continues (NAP, 2002), and the obvious need is for a continuous inflow of information to actually assess what is going on in order to be able to reduce the vulnerability.

No doubt, remote sensing can and should play a pivotal role in acquiring and availing information to assess the various impacts. This is highly facilitated with the use of indicators (Enne & Zucca, 2000; UNEP, 2000). In view of the threats exposed in (Table 1), which reflects the most endangered areas by desertification in Lebanon, the impacts of those threats, their possible indicators and whether they can be monitored by remote sensing are shown in (Table 2). About at least thirty indicators are shown in (Table 2) that can be monitored by remote sensing. Moreover, most of these indicators can be detected strongly by remote sensing, thus supplying ample data/information for vulnerability assessment.

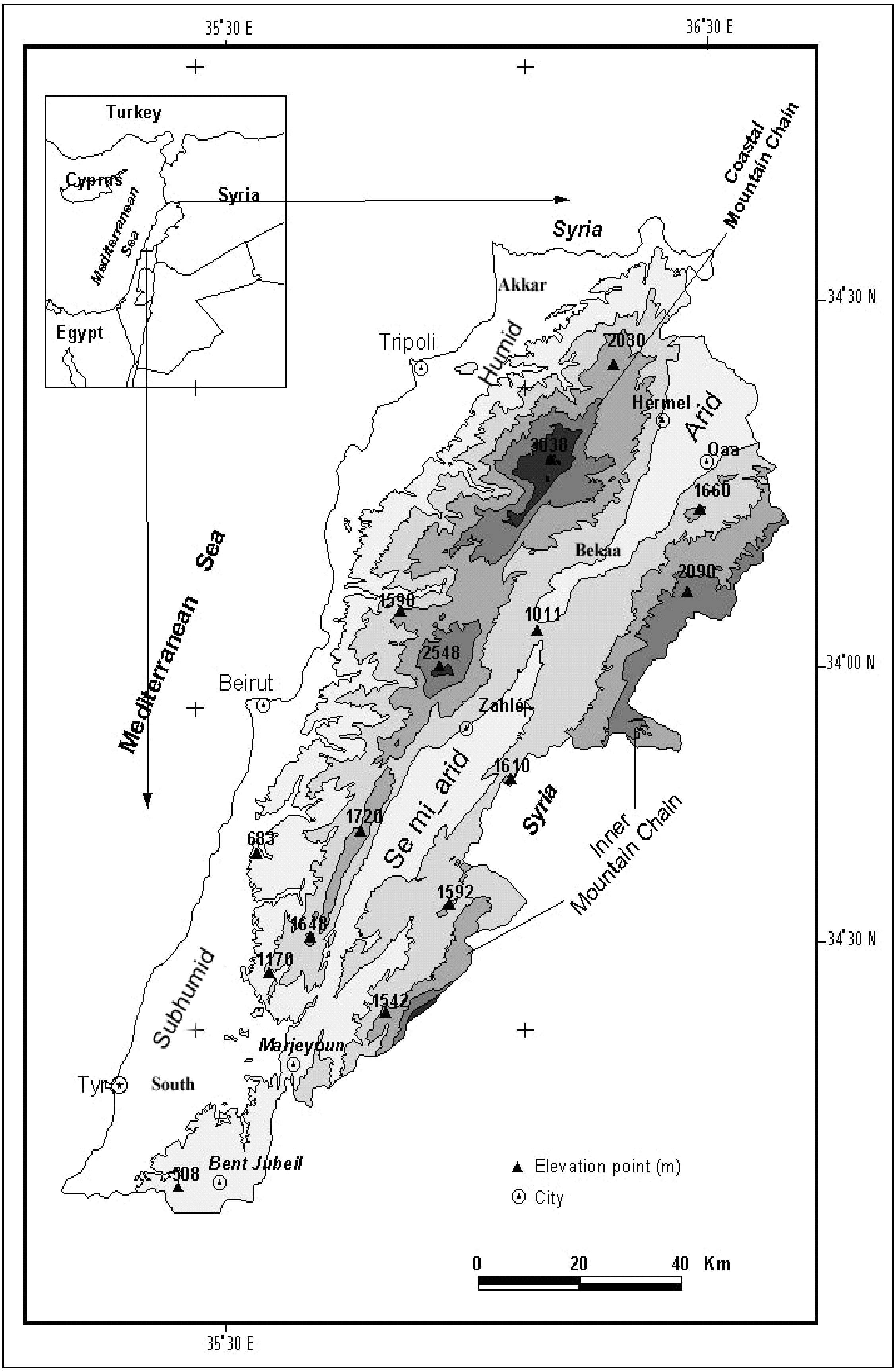

Figure 1. Lebanon along the eastern Mediterrannean, with microclimates and the three risk areas

Table 2. Availing data for impact assessment of land degradation through remote sensing (RS)

N°	Threat	Impacts	Monitoring Indicators by RS	RS detection
1.	drought	- reduced precipitation	- climatic parameters	S
		- drying soils	- soil moisture	S
		- de-greening	- plant cover, NDVI	S
2.	erosion by water	- eroded soils	- erosional features	M-S
	erosion by wind	- bare productive lands	- bare surfaces	S
		- weak plant cover	- plant cover, NDVI	S
3.	flash floods	- dissected surfaces	- dissection features	S
		- flash flood deposits	- surficial deposits	M
		- destroyed properties	- destroyed properties	S
4.	water	- unavailability	- dried streams/reservoirs	
	mismanagement	- losses/wasted	- pollution parameters (various)	S
		- bad quality (polluted)		S
		- imbalance		-
		- diseases		-
5.	excessive	- deficiency	- abandoned dry wells	S
	exploitation of	- lowering WT	(by radar if WT is shallow)	Radar
	ground water	- lowering soil moisture	- soil moisture	S
		- weak green cover	- plant cover/NDVI	S
6.	overgrazing	- deficient rangelands	- rangelands	S
		- herds grazing elsewhere	- herds movements/locations	S
		- bare trees	- comparative green cover	S
7.	uncontrolled	- excavated areas	- excavated huge holes	S
	quarrying	- distorted landscape	- erratic land surfaces	S
		- increased erosion	- erosion features	M-S
		- bare lands	- bare surfaces	S
		- diseased green cover	- green cover	S
		- polluted water	- pollution parameters (water)	S
		- air pollution	- pollution parameters (air)	M
8.	agro-practices	- degraded land	- various features	S
		- unproductive land	- bare agricultural land	S
		- soil salinization	- salty crusts	M
		- water deficiency	- dried lands	S
		- diseased agro-products	- diseased plants	S
9.	uncontrolled urban	- loss of productive land:		
	expansion	+ agriculture	- agro-cover	S
		+ forest	- forest cover	S
		+ rangeland	- rangeland cover	S
		- increased bare lands	- bare surfaces	S
		- increased erosion	- erosion features	M-S
10.	deforestation/	- loss of forest	- forest cover	S
	forest fires	- loss of ecosystem	- natural/wild life	S
		- loss of rangelands	- rangeland cover	S
		- increased bare lands	- bare surfaces	S
		- increased erosion	- erosion features	M-S
		- air pollution	- air pollution parameters	M
		- less precipitation	- climatic parameters	S
		- dryness	- soil moisture	S
11.	uncontrolled	- diseased plants	- plant cover	S
	pesticides/	- salt salinization	- salt crusts	M
	fertilizer	- water pollution	- water pollution parameters	S
12.	water pollution	- polluted water	- water pollution parameters	S
		- diseased plants	- plant cover	S
		- diseases		
13.	poverty	- quality of living	- housing type & density	S
			- cleanliness of surroundings	S
			- various urban features	S

*S: strong M: medium

The fourteen threats have different levels of “risk” in Lebanon in as much as they endanger human communities and affect their quality of living. For example, droughts and flash floods are far more dangerous on humans, and their effects in land degradation exceed any other mentioned threat. Their risk could be quantified in terms of both its nature and type. For nature, it relates to what risk constitutes, its scale, distribution, recurrence … etc. while the type is reflected in quantity, quality, degradation level … etc. These can be further analyzed in terms of their levels of impact, i.e. local or regional, and their recovery rate from the damages incurred, i.e. days, months, years … etc. Thus, the fourteen threats can be plotted on a correlation chart in view of their increasing effects on increasing vulnerability as well as their demand for information as shown in (Fig. 2). Of course, this is one approach to follow among many others. Even the well known DPSIR approach – Driving force/Pressure/Status/Impact/ and Response, has also been followed to find out how can remote sensing contribute to generate information relating to desertification by monitoring relevant indicators (Khawlie et al., 2002).

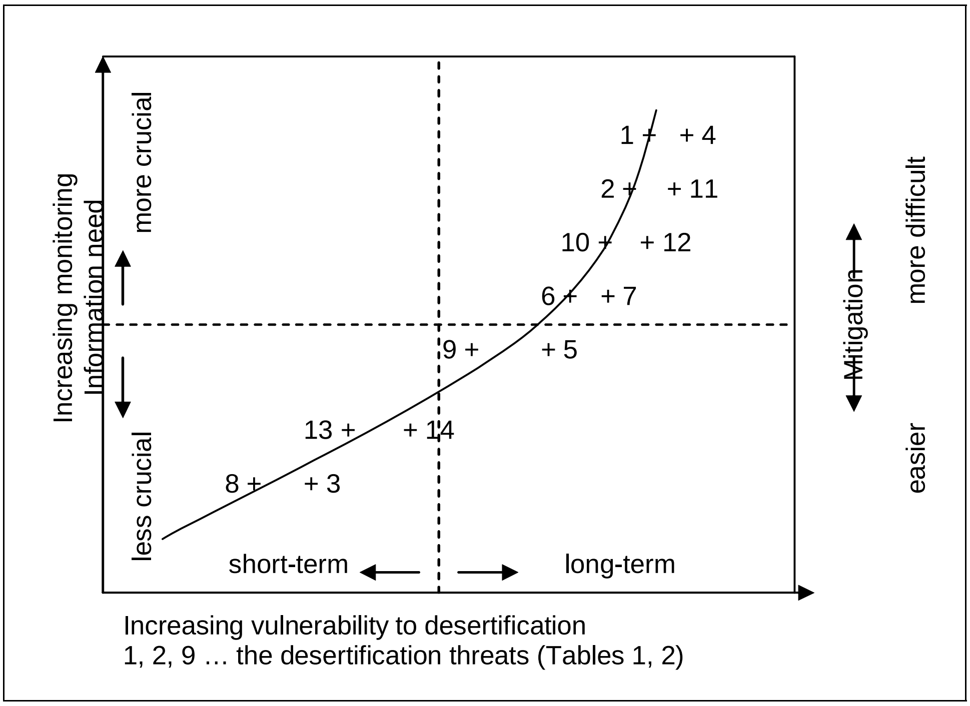

Figure. 2. Correlation between threats, information requirements and increasing vulnerability to desertification in Lebanon

If the international criteria of using remote sensing for assessing status of desertification are used here (Kharin et al., 1999), one can divide the Lebanese territory into three classes of different levels of deterioration (Khawlie, 2000): slight, moderate and severe. The international criteria used to quantify that and, therefore, the vulnerability of the country, are reflected in the extent of the following: the vegetative cover, soil wind erosion, soil water erosion and water logging. Of course these are the minimal criteria, because looking back at (Tables 1 and 2) many other criteria can be observed through remote sensing. The idea is to depend on the minimal possible but highly indicative parameters and secure information about the status of the terrain. Those criteria for deterioration levels are evaluated by indicators such as whether the vegetation cover is “modified” or “decreased” or “lost” between the present and some past time interval (Kharin et al., 1999). Similarly, for soil water erosion, one is looking for its “type”, i.e. sheet or gullies or dissection erosion, whether the “soil top is removed” or whether there is “loss of yield”. Obviously, all these vulnerability aspects require information secured through remotely sensed indicators, in order to quantify them and be able to present adaptation solutions to reduce vulnerability.

Integrated Adaptation Through Remote Sensing

It is well known now that achieving optimum solutions for such problems as encountering as land degradation needs integration of approaches and sectors. This is what knowledgeable researchers and decision-makers follow to secure through environmental management (EM). In simple terms, this requires securing the following management adaptation functions: organization, data, planning and decision. Furthermore, to raise adaptation and optimum solutions to a higher level, i.e. become more effective, environmental management (EM) must be raised to strategic sustainable environmental management (SSEM) as this encounters all sectors and inputs. In its turn, SSEM requires three basic functions: identifying goals of development, facing causes of degradation and environmental impact assessment.

The previous levels of adaptation functions can be integrated together going from one level into the other as shown in (Fig. 3). Obviously, level I is quite general as it applies to National concerns, leading into level II which serves regional concerns, then level III is definitely more focused. These functions can apply to the problem of desertification by arriving at SSEM specifically geared to desertification processes or threats (Tables 1 and 2). This is shown by the component "strategy" at the very center of the Figure. The more significant problems, or threats, may vary geographically, and they can be prioritized through this integrated approach. But generally, (Fig. 2) reflects on the increasing vulnerability of Lebanon, so a sort of National priority(ies) can be established following the integrated approach which increases adaptation capacities thus reducing vulnerabilities. The central function in (Fig. 3) is the strategy, which is built on the surrounding inputs that are all information – dependent. Thus, it can be called integrated information strategic assessment (IISA).

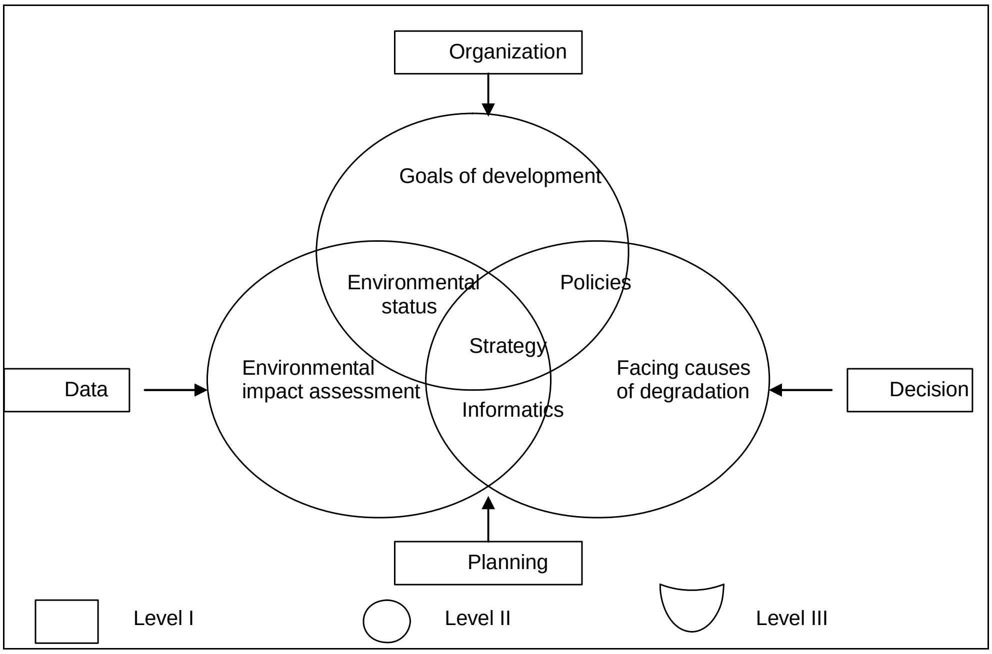

Figure 3. The raising of levels of environmental assessment through integration of functions to reduce vulnerability by SSEM

Coming back to information as it is the backbone of IISA, one is interested to know how much of that information at the highest level, i.e. Level III is, or can be supplied by remote sensing. This can be determined by what are the major requirements of Level III functions. They are the following:

Environmental status	Informatics	Policies	Strategy
1. change detection	4. criteria & standards	*7. priorities*	*10. development*
2. loss of resources	5. monitoring & indicators	8. trends	*11. optimum solutions*
3. pollution	6. quick, total, accurate information	9. projection & protection	*12. assessment & feedback*

Out of the twelve major requirements cited above, eight may depend on information directly supplied by remote sensing, while the other four (in italics) depend indirectly on that kind of information. Fitting this back in (Fig. 2) and (Table 2), and remembering what was mentioned at the beginning of the paper that the major setback in Lebanon is lack of data/information, one can easily see how remote sensing can significantly contribute to reducing Lebanon's vulnerability to desertification through supply of information.

References

[1] Bou Kheir, R., Girard, M-C., Khawlie, M., & Abdallah, C. (2001). Erosion hydrique des sols dans les milieux méditerranéens: une revue bibliographique. J. Etude et Gestion des Sols, 8:4:231-245.

[2] Brooks, D. (2000). Access to water in the Eastern Mediterranean. in: Water Balances in the Eastern Mediterranean. Brooks & Mehmet (ed.), IDRC, Canada.

[3] CTM-ERS (1999). Desertification Monitoring and Control: Analysis of Remote Sensing – Based Projects in the Mediterranean. Centro di Telerilevamento Mediterraneo-UNEP Environmental Remote Sensing Center – Palermo, Italy.

[4] DAG. (1962). Topographic maps of Lebanon (with land cover), 1:20000. Directorate of Army Geographic Affairs. Beirut.

[5] FAO. (1990). Land cover maps of Lebanon (from satellite imagery), 1:50000. FAO, Ministry of Agriculture. Beirut.

[6] Enne, G. & Zucca, C. (2000). Desertification indicators for the European Mediterranean region. UNCCD, ANPA, NRDUS, Rome.

[7] Gentile, A.R. (1998). From national monitoring to European reporting: the EEA framework for policy relevant environmental indicators. Proceed. International Seminar on Indicators for Assessing Desertification in the Mediterranean. Portos Torres, Italy.

[8] Jomaa, I. & Khawlie, M. (2002). Land use/land cover change detection 1987-2000, Baalbeck-Hermel area, Lebanon. Workshop on Advanced Techniques for Monitoring the Environment/Aid to Decision Making: GIS/RS to combat desertification. MAICH, Chania, Greece.

[9] Kharin, N., Tateishi, R., & Harahsheh, H. (1999). Degradation of the dry lands of Asia. CEReS-Chiba University. Japan.

[10] Khawlie, M. & Asmar, F. (2000). Constraints and challenges of desertification monitoring and assessment in Lebanon. UNCCD, Asian Regional Thematic Network on Desertification Monitoring and Assessment (TPN 1). Tokyo.

[11] Khawlie, M. (2001). The impacts of climate change on water resources of Lebanon-eastern Mediterranean. RICAMARE Workshop, FEEM Bull. NRM/45.2001. Italy.

[12] Khawlie, M., Hasmann, B., Darwish, T., Lichaa El-Khoury, D., Faour, G., Abdallah, C., & Bou Kheir, R., (2001). A knowledge-based integrated system to monitor desertification in Lebanon through remote sensing. Joint Workshop of ISPRS WG1/2, 1/5 and IV/7. High Resolution Mapping from Space 2001. Hannover, Germany.

[13] Khawlie, M., Hansmann, B., Darwish, T., Haddad, T., Jomaa, I., & Bou Kheir, R. (2002). Enhancing the role of remote sensing for encountering desertification in Lebanon. Proceed. 2nd Workshop EARSeL, Remote Sensing for Developing Countries. Bonn, Germany.

[14] LEDO. (2001). Lebanon Environment and Development Observatory (program). Ministry of Environment. Beirut.

[15] Masri, T., Khawlie, M., & Faour G. (2002). Land cover change and driving forces the last 40 years in Lebanon. Lebanese Science Journal Vol.3:2.

[16] MoE. (1995). Lebanon Assessment of the State of the Environment. Ministry of Environment, Beirut.

[17] MoE (1999). Lebanon's National Communication – Climate Change. Ministry of Environment, Beirut.

[18] NAP (2002). Lebanese National Action Program. UNCCD, GTZ, UNDP. Beirut.

[19] Sadek, A.K. & Barghouti, S. (1994). The water problems of the Arab World: Management of scarce resources. in: Water in the Arab World: Perspectives and Prognoses. Rogers & Lydon (ed.), AUC Press, Egypt.

[20] UNEP-MAP (2000). 130 indicators for sustainable development in the Mediterranean region. UNEP, Blue Plan. Sophia Anitpolis.